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Improved hydrology over peatlands in the GEOS-5 land modeling system

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Peatlands represent an important global carbon pool that accumulated under permanently wet conditions in specific geological and climatic settings over thousands of years. The carbon balance and greenhouse gas emissions of peatlands are closely coupled to water table dynamics. Consequently, the future carbon balance and emissions over peatlands are strongly dependent on how hydrology in peatlands will react to changing boundary conditions, e.g. due to climate change or regional water level drawdown of connected aquifers or streams. Global land surface modeling over organic-rich regions can provide valuable global-scale insights on where and how peatlands are in transition due to changing boundary conditions, in particular when combining model results with satellite data observations. However, the current global land surface models are not able to reproduce typical hydrological dynamics in peatlands well. We implemented specific structural and parametric changes to account for key hydrological characteristics of peatlands into the Catchment Land Surface Model (CLSM, Koster et al. 2000), which is the land part of NASA's Goddard Earth Observing System Model, version 5 (GEOS-5), a general circulation model. The main modifications pertain to the modeling of partial inundation, and the definition of peatland-specific runoff and evapotranspiration schemes. We ran a set of simulations for peatlands of the Northern Hemisphere using different CLSM configurations and validated the results with a newly compiled global in-situ dataset of water table depths in peatlands.

The results demonstrate that an update of soil hydraulic properties for peat soils alone does not improve the performance of CLSM over peatlands. However, structural model changes for peatlands are able to improve the skill metrics for water table depth. The validation results for the water table depth indicate a reduction of the bias from 2.5 to 0.2 m, and an improvement of the temporal correlation coefficient from 0.5 to 0.68, and from 0.48 to 0.65 for the anomalies. Our validation data set includes both bogs (rain-fed) and fens (ground and/or surface water influence) and reveals that the metrics improved less for fens. In addition, a comparison of evapotranspiration and soil moisture estimates over peatlands will be presented, albeit only with limited ground-based validation data. We will discuss strengths and weaknesses of the new model by focusing on time series of specific validation sites.